cutta gardens from Mauritius, and the unpleasant results which ensue if their destruction is not conducted on special lines.

Let no one, however, imagine that an Indian life has not its lighter side. What, for instance, can equal the glory of its sunsets, so graphically described by the author, or the luxuriance and beauty of its gardens, which he brings to our notice with the aid of both camera and pen? As an example of what can be done in the way of effect with foliage alone, we reproduce the accompanying illustration, with which we must, reluctantly, take leave of a charming, thoughtful, and instructive work. R. L.

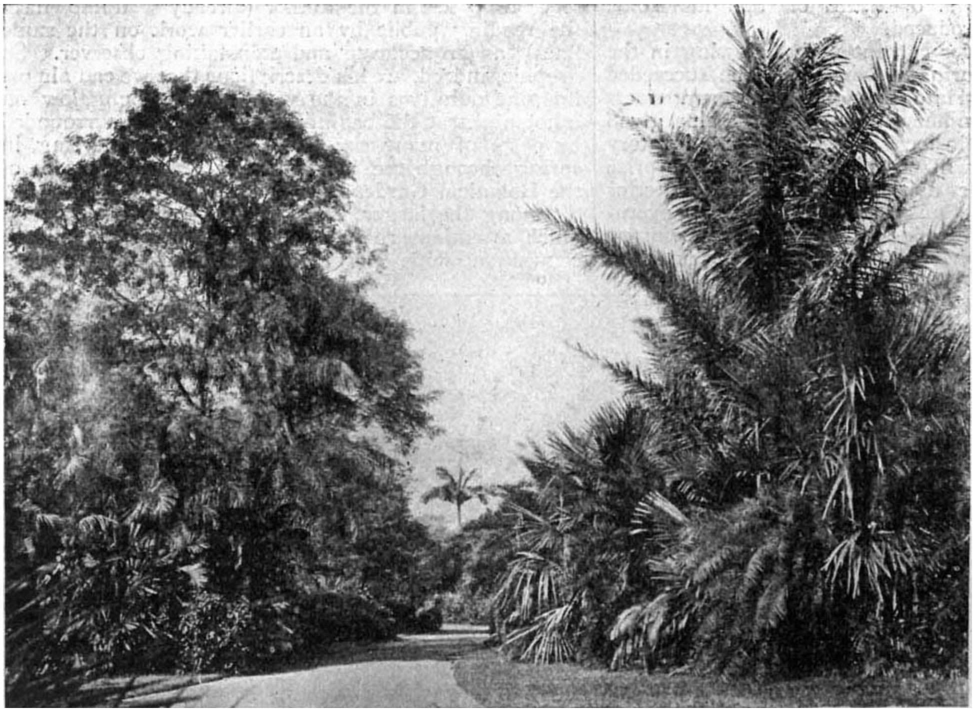

Fig. 2.—Palms in an Indian Garden. From "Plagues and Pleasures of Life in Bengal."

"KIMBERLITE" AND THE SOURCE OF THE DIAMOND IN SOUTH AFRICA.

THE origin of the volcanic pipes of South Africa and the genesis of the diamonds contained in their "blue-ground" filling are as productive of controversy as that other geological puzzle—the source of the gold in the Witwatersrand conglomerates—the discussion of which was revived by Prof. J W. Gregory at a recent meeting of the Institute of Mining and Metallurgy; and agreement among the disputants is as little likely to be arrived at in the one case as in the other. Quite a crop of papers on the diamond-pipes has recently appeared,[1] and a perusal of these reveals so remarkable a variation of opinion that it may perhaps serve a useful purpose to give in these columns a brief summary of the different views as to the nature of the original matrix of the diamond and the place in which it was produced, that have been put forward from time to time since the discovery of the "dry diggings" at Kimberley in 1870.

Prof. E. Cohen, who visited the diamond field in 1872, gave the first scientific explanation of the origin of the volcanic pipes in a letter addressed to Prof. Leonhard, and published in the "Neues Jahrbuch für Mineralogie" (1872, p. 859). According to Cohen the diamond occurrences represent the centres of tuff-eruptions, whereby the greater part of the erupted material was provided by older crystalline rocks underlying the present known formations. These furnished not only the diamonds, but probably most of the accompanying minerals. Forced violently upward by volcanic explosions, the shattered rocks became pulverised, and the diamonds either survived as complete crystals or were broken into fragments (the "splints" of the dealers). This view explains the fragmentary character of the minerals that accompany the diamond; it also accounts for the presence of so many fragments of crystalline rocks in the pipe-material ("blue-ground"), and for the strongly brecciated character of the latter. Cohen's view was subsequently somewhat modified by Chaper (Bull. Soc. Minér. de France, ii., 1879, p. 195), who found it necessary to assume a repetition of explosive eruptions in order to account for the variation in one and the same pipe of large masses of the blue ground in colour, mineral composition, richness in diamonds, &c.

On the other hand, Dunn, who wrote in 1874 (Quart. Journ. Geol. Soc., xxx., p. 54), described the blue ground as a "decomposed gabbro or euphotide"; while Maskelyne and Flight, who gave the first description of the microscopic character of the diamantiferous rock (Quart. Journ. Geol. Soc., xxx., 1874, p. 406), considered that it "was probably the original home of the diamond, possibly at the places of its contact with carbonaceous shales." These ideas were further developed by Carvill Lewis in papers read before the British Association in 1886 and 1887, and subsequently published by Prof. T. G. Bonney under the title "Papers and Notes on the Genesis and Matrix of the Diamond." After an elaborate microscopic investigation made in Prof. Rosenbusch's laboratory in Heidelberg, Lewis pronounced the rock to be a true eruptive lava—"a porphyritic volcanic peridotite of basaltic structure, or, according to Rosenbusch's nomenclature, the palæo-volcanic representative of a biotite-bronzite-dunite, being an olivine-bronzite-picrite rich in biotite." To this rock he gave the name of kimberlite, distinguishing between *kimberlite proper,* a typical porphyritic lava; *kimberlite breccia,* the same lava broken and crushed by volcanic movements within the pipe, and crowded with included fragments of foreign rock; and *kimberlite tuff,* the fragmental and tufaceous portion of the same volcanic rock, all these varieties passing into one another and occurring together in the same neck or crater. The kimberlite breccia constitutes, according to Carvill Lewis, the greater portion of the pipe material, but it is traversed by dykes of kimberlite proper, and contains streaks and patches of a soft, "soapy" material which appears to be kimberlite tuff. As to the diamond, it is as much a constituent of kimberlite as the more commonly occurring biotite, garnet, titanic and chromic iron and perovskite, and consequently must have been produced *in situ.*

---

[1] A. W. Rogers and A. L. du Toit: The Sutherland Volcanic Pipes and their Relationship to other Vents in S. Africa (Trans. S.A. Phil. Soc., vol xv., p. 61, 1904).

H. S. Harger: The Diamond Pipes and Fissures of South Africa (Trans. Geol. Soc. S.A., vol. viii., p. 110, 1905).

G. S. Corstorphine: The Occurrence in Kimberlite of Garnet-pyroxene Nodules carrying Diamonds (Trans. Geol. Soc. S.A., vol. x., p. 65, 1907).

F. W. Voit: Kimberlite Dykes and Pipes (Trans. Geol. Soc. S.A., vol. x., p. 69, 1907).

F. W Voit: The Origin of Diamonds (Trans. Geol. Soc., S.A., vol. x., p. 75, 1907).

A. L. du Toit: Geological Survey of the Eastern Portion of Griqualand West (Eleventh Ann. Rep. Geol. Com. Cape of Good Hope, p. 135, 1906).

A. Macco: Ueber die südafrikanischen Diamantlagerstätten (Zeitsch. der deutsch. geol. Gesellsch., vol. lix., p. 76, 1907).

R. Beck: Untersuchungen über einige südafrikanische Diamantenlagerstätten (Zeitsch. der deutsch. geol. Gesellsch., p. 276, 1907).

From this view Bonney was led to dissent by a microscopic examination, made in 1899, of specimens from the Newlands mines in West Griqualand ("The Parent Rock of the Diamond in South Africa," Proc. Roy. Soc, vol. lxv., 1899, p 620). Among these specimens was a rounded boulder of a rock which was described by him as a "holocrystalline mixture of chrome-diopside and garnet, with a few small enclosures of olivine, in other words, a variety of ecklogite and of igneous origin." The interest of the specimen lay in the fact that it contained diamonds, and from this Bonney drew the momentous conclusion that the birth-place of the diamond and of the garnet, pyroxenes, olivine, &c., was not the "blue ground" itself, but the ecklogite which occurred in the latter as foreign boulders. He further concluded, from the smooth exterior of the specimen examined, that the boulders were water-worn, and were derived from a conglomerate bed "at the base of the sedimentary series in proximity to a crystalline floor." The blue ground then, according to Bonney, is a true breccia produced by the destruction of both crystalline and sedimentary rocks, the "result of shattering explosions followed by solfataric action."

R. Beck (*Zeits. für prakt. Geol.*, 1879, p. 417), to whom similar specimens from the Newlands mines had been sent, differed from Bonney as to the origin of the so-called boulders of ecklogite, which he considered to be concretions formed at great depth in the kimberlite magma—like the well-known olivine nodules in the basalt of Finkenberg, near Bonn, described by Rosenbusch and others as early segregations from the basalt magma. The serpentine breccia which represents the present condition of the kimberlite magma contains all the constituents of the nodules. The rounding of the boulders is to be ascribed to attrition during the upward course of the pyroclastic material in the pipe. Beck agreed with Bonney that the diamonds were formed at great depth, but for a different reason, namely, that only at great depths could such coarse-grained granular segregations from the magma have been produced. In a more recent paper (*Zeits. der deutsch. geol. Gesellsch.*, 1907, p. 226), Beck gives results of a further examination of the Newlands ecklogite, which, by the way, he proposes to call "Griquaite." In addition to the constituents already named, he finds biotite, perovskite, zircon, rutile, and graphite. He repeats his conclusion that the "boulders" are deep-seated (intra-telluric) segregations from the same magma from which the pipe material is derived, and ascribes the genesis of the diamond to the presence in the original magma of metallic carbides, it being his opinion that not only the diamonds contained in the ecklogite, but also the isolated individuals in the blue ground, must have been formed at great depth.

The views of the earlier writers can be grouped into two distinct theories:—(1) The pipe material is a breccia or tuff produced with its contained diamonds, by violent volcanic agencies, from pre-existing rocks (Cohen, Chaper, Bonney, Beck). (2) It is a true eruptive lava which has solidified *in situ,* the diamonds having been separated out during this consolidation (Dunn, Maskelyne, Flight, Carvill Lewis).

Among the recent writers on the subject, H. S. Harger and G. S. Corstorphine support the view that the diamonds have been derived from a deep-seated source, the former mentioning that out of a parcel of 372 stones examined by him, 119 were found to be broken fragments of original crystals. F. W. Voit, on the other hand, regards the "splints" as either imperfectly formed crystals or as having been broken during the processes of mining and washing. (He would find it difficult, however, to explain the fractured character of the Cullinan diamond[1] by either of these hypotheses.) Voit regards the pipes as embryonic volcanoes. According to him, the igneous magma which rose in the pipes, being unable to reach the surface, was forced to solidify under the pressure of the superincumbent strata in circular or elongated moulds, thus giving rise to what he terms "conical batholites." While the extruding magma was still in the semi-plastic state, it was agitated by further gaseous eruptions, to the action of which the brecciated character of the blue ground is largely to be ascribed. He regards the ecklogite "boulders" as concretions of the kimberlite magma, formed *in situ.* He admits, however, the presence in the blue ground of boulders of granite, gneiss and crystalline schists of exotic origin.

A. L. du Toit, of the Cape Geological Commission, who during 1906 was working in the Kimberley district, has formulated a theory which combines parts of both the earlier views, and is more in accord with modern ideas of petrogenesis. According to him, kimberlite is a hybrid rock derived from a deep-seated magma (having the composition of a limburgite) which incorporated the shattered fragments of the various holocrystalline basic and ultra-basic components of the floor through which it broke. During its further ascent the eruptive mass caught up and included in its body fragments of the sedimentary beds through which it passed. A portion of its brecciated character, however, is to be attributed to movements during consolidation. Of the minerals found in the blue ground, du Toit considers the tremolite, smaragdite, epidote, orthite, tourmaline, muscovite, biotite, apatite and zircon to be xenocrysts derived from deep-seated rocks of acid composition (granite, gneiss, pegmatite, &c.); while he regards the olivine, pyroxenes, garnet, ilmenite, magnetite, chromite, spinel, sphene, kyanite, and the diamond as xenocrysts derived from basic and ultra-basic holocrystalline rocks. In addition, the original eruptive magma gave rise on consolidation to authigenic crystals of olivine, diopside, brown mica, magnetite, ilmenite, chromite, apatite, perovskite, nepheline and melilite.

In support of his view, du Toit gives instances of strong contact metamorphism effected by the pipe material during its intrusion. Few cases of contact-metamorphism, however, have hitherto been observed. Corstorphine (*loc. cit.*, p. 65), for instance, states that the fragments of sandstone, shale, &c., that he has found enclosed in the blue ground are conspicuously unaltered.

---

[1] *Vide* F. H. Hatch and G. S. Corstorphine, "A Description of the Big Diamond recently found in the Premier Mine, Transvaal (*Geol. Mag.*, p. 170, 1905).

Much of the recent controversy has centred round the relation of the kimberlite dykes to the pipes. The fact that material of practically identical character to the pipe rock, and similarly brecciated, occurs in the form of dykes has long been known; but the latter have hitherto attracted but little attention, owing to the fact that the dyke material either carries no diamonds or so few as to be unworkable at a profit.

There can be no doubt that the dykes are genetically connected with the pipes, but were they formed contemporaneously, or did the dykes precede the pipes or *vice versâ?* Dr. Voit states that the pipes are younger than the dykes, which in all cases terminate, according to him, at the pipe-walls. Besides, fragments of dyke rock occur in the pipes, but pipe rock is never found in the dykes. Although chemically identical magmas, there are slight mineralogical distinctions, due, probably, to the different rate of cooling, which enable the rocks to be easily identified. Du Toit advocates the contrary view, namely, that the pipes and fissures have been formed contemporaneously. Between the extremes of occurrence in pipes or dykes he traces every gradation, and mentions "fissure-swellings," which, though dyke-like, expand at one or more points. Almost every pipe will be found to have one or more dyke-like offshoots, if not at the surface, at some greater depth. In the Newlands group, the pipes are connected below ground by a narrow dyke of kimberlite; on Secretaris, west of Kimberley, there are fissures with one or more little swellings on them, and there are numerous dykes and veins varying in width from mere stringers to belts of many feet. The strike of the fissures corresponds in some instances to that of the enclosing rocks (Newlands, Smith, and Peiser mines), indicating that the intrusion followed planes of physical weakness.

Instances might be multiplied to show the differences of opinion that obtain among South African geologists with regard to these interesting occurrences. They only emphasise the difficulties of the problems awaiting solution.

One word as to the date of intrusion. The pipes and fissures are later than the Karroo dolerites, which, in their turn, cut the Stormberg lavas. They are therefore at least of post-Rhætic age. If the melilite-basalt pipes of Sutherland are connected in origin with an intrusion of melilite-basalt in the Uitenhage beds at Spiegel River (Heidelberg, Cape Colony), then the occurrences of kimberlite are of post-Neocomian age (*vide* Rogers and du Toit, *loc. cit.*).

F. H. HATCH.

THE INDUCTION OF ANÆSTHESIA BY CHLOROFORM.

THE inquiry which was initiated seven years ago by the Council of the British Medical Association into the many-sided problem of chloroform-anæsthesia has added greatly to our knowledge, and directed particular attention to the fact that the administration of an amount of chloroform vapour above 2 per cent. in the inspired air is fraught with danger to the patient. The scope of this inquiry has been further supplemented and extended by independent researches carried out in this country and in France.

The view has been held, and to some extent verified by experiments, that during the progress of anæsthesia the drug was absorbed by the corpuscles rather than by the plasma of blood. The experiments of Benjamin Moore and H. E. Roaf first definitely proved that *in vitro,* with an adequate concentration or solution tension of chloroform in the blood, easily dissociable compounds or aggregations were formed between the drug and the proteins, including hæmoglobin, of the blood. It was a natural inference from these experiments that the production of anæsthesia, either in isolated cells or in unicellular or multicellular organisms, was due to the formation of such compounds between cell-protoplasm and chloroform. With a very small constant quantity of chloroform, 1 per 100,000, in blood it has been found that the anæsthetic effect is in no sense a cumulative one; the degree to which a living tissue is affected depends entirely upon the concentration of the chloroform in the blood, and therefore in the living cell, for the degree of anæsthesia remains constant, and persists for only so long as a definite solution pressure is maintained. Any given grade of anæsthesia is therefore entirely independent of the total amount of chloroform which is supplied at an adequate concentration. In the induction of anæsthesia in man the various stages from slight to profound must therefore essentially depend upon the gradually rising pressure of chloroform in the blood. When the amount of chloroform in inspired air is very low, the induction of anæsthesia is impossible; while that too high a percentage is lethal, the unfortunate accidents which occur from time to time bear abundant witness.

The rate of absorption of chloroform during the induction of anæsthesia has been studied by many observers, most of whom have attempted a solution of this problem by ascertaining the degree to which the lungs are ventilated during narcosis, and the extent to which chloroform is apparently retained by the body. This is determined by estimating the difference between the chloroform-content of inspired and expired air. In the case of inspired air this can easily be done with accuracy, but, especially with a low percentage of chloroform, the corrections which are necessary for temperature, amount of carbon-dioxide and aqueous vapour are so great as to render an accurate determination of the amount of chloroform in expired air a matter of much difficulty.

The rate at which chloroform is taken up by the blood can, however, be directly measured. In three papers just published in the Proceedings of the Royal Society, Dr. G. A. Buckmaster and Mr. J. A. Gardner have described the exact procedure of their experiments, which were undertaken with the view of ascertaining the function of the red corpuscles in anæsthesia produced by chloroform. Two of the papers fully describe experimental studies on "The rate of the assumption of chloroform by the blood during anæsthesia," and "The rate of elimination of chloroform from the blood after anæsthesia."

Hitherto an exact determination of chloroform in blood has been found to be difficult. It is not possible to use Neumann's method for chlorides. French observers, Tissot, Mansion, and Nicloux, have employed a method which is based on Dumas's reaction, which, as carried out by Nicloux, is rapid, convenient, and capable of giving satisfactory results, though it does not possess such a high degree of precision as an exact chemical method as does the one which was introduced by Carius for the determination of chlorine in organic compounds. This method was first used by Buckmaster and Gardner in their experiments on the anæsthetic and lethal quantity of chloroform in blood. The maximum error of this method never exceeds five per cent., and is generally much less. The amount of chloroform in the blood at any stage of anæsthesia is calculated from the difference between the chlorine-content of the blood of each individual animal before and after the induction of anæsthesia.